ESQD REDUCTION BY ANALYSIS AND ANALOGY

prepared by

Paul E. Montanaro

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ESQD REDUCTION BY ANALYSIS AND ANALOGY

by

Paul E. Montanaro
Indian Head Division/Naval Surface Warfare Center

ABSTRACT

The explosive-safety quantity-distance (ESQD) requirements for buildings given in DOD 6055.9-STD and its Navy implementation OP-5 are not written in stone. Both documents provide that "...DDESB approved analyses and/or approved tests may be used to determine minimal distances for both primary and secondary fragments. DDESB Technical Paper 13 ... is an example of a method to determine minimal distances for building debris." This paper will show by example the use of the TP 13 used in combination with other methods for the estimation of ESQD ranges for several buildings. The examples are all taken from real situations with real siting constraints. They demonstrate that in some instances the DOD standards cannot be relaxed; however, for many situations reduced ESQD arcs can be obtained.

ESQD REDUCTION METHODOLOGY

The explosive safety quantity-distance (ESQD) requirements for explosive buildings are found in DOD 6055.9-STD[1] and the Navy interpretation of this standard OP-5[2]. ESQD's are based on both airblast and debris criteria. This paper will concern itself with the debris aspects only. The debris Inhabited Building Distance (IBD) ESQD range is the range at which the hazardous debris density falls below a value of 1 per 600 ft^2, where hazardous debris is defined as having an impact energy of 58 ft - lbs or greater.

Typically for buildings with explosive limits below and above 100 lbs., the IBD distances would be 670 ft and 1250 ft respectively. However these distances can be reduced by using DDESB approved analyses and / or tests, if the distances from the analyses or tests are calculated to be less than those given in the standards. In this paper various analysis methods and techniques will be described which can be used to determine if the ESQD distances may safely be reduced.

The primary approved method used for analysis of explosive building debris is described in Technical Paper 13[3] (TP 13). This method uses three computer codes called Shock, Frang, and MUDEMIMP, and together they are referred to as the DISPRE model. The Shock code is used to calculate shock impulses on building walls and the roof. Frang calculates gas impulses for the same situation. MUDEMIMP uses the results from Shock and Frang along with building structural information to calculate hazardous debris distances for the building. It is from these debris distances that the debris ESQD's are derived.

The calculations used in the DISPRE model are often very complex and time consuming, but they can result in a reduction in ESQD distances. However, even when they do not result in a reduction, several methods can be used to try to reduce the calculated distances to an acceptable value. The methods discussed here are all applied after initial calculations have been performed with the DISPRE model.

Method 1: Restrict Explosive Placement within the Building

The DISPRE model performs separate debris calculations for each building component (walls, roof, etc.). The model provides 4 separate ESQD distances in the direction of the 4 walls of the building. Many times a building's ESQD arc is only in violation in one direction from the building. In this case, the standoff (distance between the explosive charge and the component of interest) could be increased to try to reduce the shock impulse on a wall and therefore reduce its debris distances. This method was used successfully in Example 1 to reduce the calculated distances to acceptable levels. This doesn't always work, however, because the gas impulse tends to increase with increased standoff due to reduced venting (i. e., at reduced standoffs, the direct shock may cause larger portions of the wall to locally fail, producing an increased vent area). The explosive standoff could also be increased to more than one wall on different sides of the building, but this may result in reduced usability of the building because the usable interior area would decrease.

Method 2: Reduce the Explosive Limits for the Building

This method may be a last resort, but often buildings do not have a realistically set explosive limit, and the amount of explosives actually stored in them is much less than the limit. By reducing the explosive limit, the hazardous debris distances can often be reduced significantly.

Method 3: Construct a New or Use Existing External Barricades to Limit Debris Hazards in Critical Directions

As stated previously, many times the hazard arc from a building is only a problem in one direction. By constructing a relatively inexpensive barricade on one side of the building, the effects of hazardous debris from the walls of the building in this direction can be eliminated. The barricade must be robust enough to withstand the blast and debris, and not itself become a source of hazardous debris. It should be at least as high and wide as the building and could be constructed out of reinforced concrete or an earth berm. Better yet, if there is an existing building in the direction of interest that is large enough to block the wall debris, this can be treated as a barrier.

The DISPRE model calculates debris hazard ranges for the walls separately from those of the roof of a building. Since a barricade only affects wall debris, roof debris must still be considered; however because of their high initial launch angles, roof debris usually doesn't travel nearly as far as wall debris.

Method 4: Add Dividing Walls to Limit the Maximum Credible Event (MCE)

In some explosive storage buildings, it may be possible to separate explosive items into bays in which each bay is separated by a dividing wall constructed from material such as reinforced concrete. The function of the dividers would be to prevent sympathetic detonation from one bay to an adjacent bay, thereby reducing the MCE for the building by the number of bays in the building. Generally the dividing walls should be large enough to adequately protect items in one bay from another, but not necessarily cover the entire width or height of the interior. If the dividing wall created an entirely separate room in the building, it would a cause increased gas impulse because of the reduced room volume.

The required strength of the dividing walls would depend on the weight of the explosives in each bay. For very large explosive weights, it may not be possible to protect items in one bay from another. For small explosive weights however, steel cubicles open at one end could be used. For example a building containing 2 lbs of explosive could be separated into 4 cubicles each containing 0.5 lbs. This would create a MCE of 0.5 lbs and would change the ESQD distance from 670 ft to 50 ft (see Table G-4 in OP-5).

Method 5: Examine Terrain Effects

In some instances, terrain effects can significantly reduce the hazardous debris distances for an explosive building. For example, when a building lies at the bottom of a hill, the hill can act as a barricade for wall debris if the hill is higher than the wall. Even if it is not that high, it can still block a significant amount of debris or stop them from rolling. Computer codes such as TRAJ[4] (which calculates trajectories for debris) can be used to examine the effect of the terrain on various types of debris to reduce the debris distances.

EXAMPLES

The following are real life examples in which the already described methods were used to reduce the ESQD arcs from their default values.

Example 1

In this example, a torpedo holding facility was analyzed using the DISPRE model. The building can contain up to four torpedoes, each with up to 176 lbs of Hazard Division 1.1 material. In this scenario, the default ESQD distance would have been 1250 ft. The analysis was performed to try to minimize the ESQD arcs using Methods 1 and 4. The building was divided into 4 bays by reinforced concrete dividers (see Figure 1). The placement of each torpedo was restricted to the center of each bay, and the dividers were sufficient to prevent sympathetic detonation between torpedoes in adjacent bays. It should be pointed out that the failure of the concrete dividers under the explosive load produced by the detonation of 176 lbs was also considered. It was determined that neither the direct blast nor the impact of the wall debris would initiate an adjacent warhead. This reduced the MCE for the building to only one torpedo or 176 lbs. The ESQD arcs were then calculated to be 310 ft, 780 ft, and 250 ft for the front wall, side walls, and rear wall respectively. A great reduction compared to the original 1250 ft arc.

Example 2

An explosive operating building was examined using the DISPRE model. It had a 20 lb TNT equivalent explosive limit. The default ESQD distance for this building was 670 ft, yet the property line was only 320 ft away. Method 5 was used because the building was at the bottom of a significant hill in the direction of interest toward the property line (see Figure 2). In this case, the hill had the effect of eliminating debris roll, which reduced the ESQD arc to 275 ft which was within the property line.

Example 3

For this final example, an explosive processing building was examined again using DISPRE. The building could contain up to 50 lbs of explosive material. The goal was to reduce the ESQD arc from the default distance of 670 ft to 540 ft or less, in the direction of a nearby building. Initial DISPRE calculations resulted in a calculated distance of 1080 ft. Although this was greater than 670 ft, 670 ft could still have be used for the ESQD arc because the default distance can always be used if it is lower than the calculated one. However by increasing the explosive standoff (Method 1) to the wall of interest from 1.5 to 6 ft, the calculated distance was reduced from 1080 ft to the needed 540 ft. Figure 3 shows the explosive placement restrictions for the building.

SUMMARY

One or more of the previously described methods can be used in conjunction with the DISPRE model calculations to try to reduce the ESQD distances for an explosive building. The advantages and disadvantages for each are summarized below.

Advantages	Disadvantages
Method 1 (Restrict Explosive Placement)	
Can significantly reduce arc	Reduces usable space in building
Doesn't cost anything	Usually only reduces arc in one direction
Method 2 (Reduce Explosive Limits)	
Can significantly reduce arc	Reduces usability of building
Method 3 (Construct Barricades)	
Blocks wall debris	Adds cost
	Does not affect roof debris
Method 4 (Add Dividing Walls)	
Reduces MCE	Adds cost
	Doesn't work well for large charges
Method 5 (Examine Terrain Effects)	
Can block or reduce range of debris	Additional calculations required
Doesn't cost anything	Significant terrain is needed for any effect

REFERENCES

1. DOD 6055.9-STD, DOD AMMUNITION AND EXPLOSIVES SAFETY STANDARDS, October 1992.

2. Ammunition and Explosives Ashore--Safety Regulations For Handling, Storing, Production, Renovation, and Shipping, NAVSEA OP-5 VOLUME 1, Sixth Revision, Change 1, 15 November 1995.

3. Prediction of Building Debris For Quantity-Distance Siting, Technical Paper 13, Department of Defense Explosive Safety Board.

4. Montanaro, P. E., "TRAJ--A Two Dimensional Trajectory Program For Personal Computers", Minutes of the Twenty-Fourth Explosives Safety Seminar, St. Louis, Missouri, 28-30 Aug 1990.

FIGURE 1: Torpedo Holding Facility (Top View)

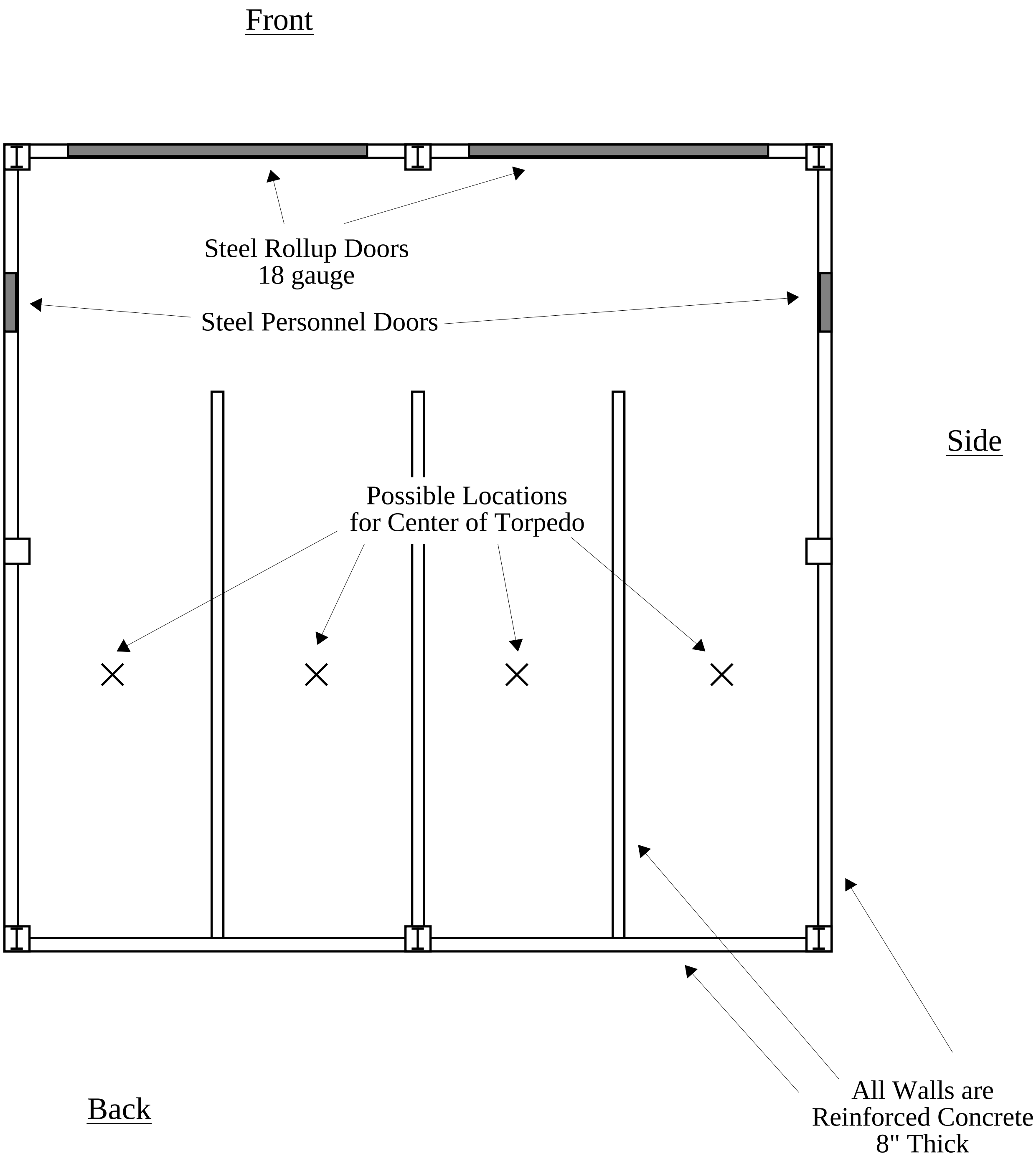

FIGURE 2: Building Terrain Profile

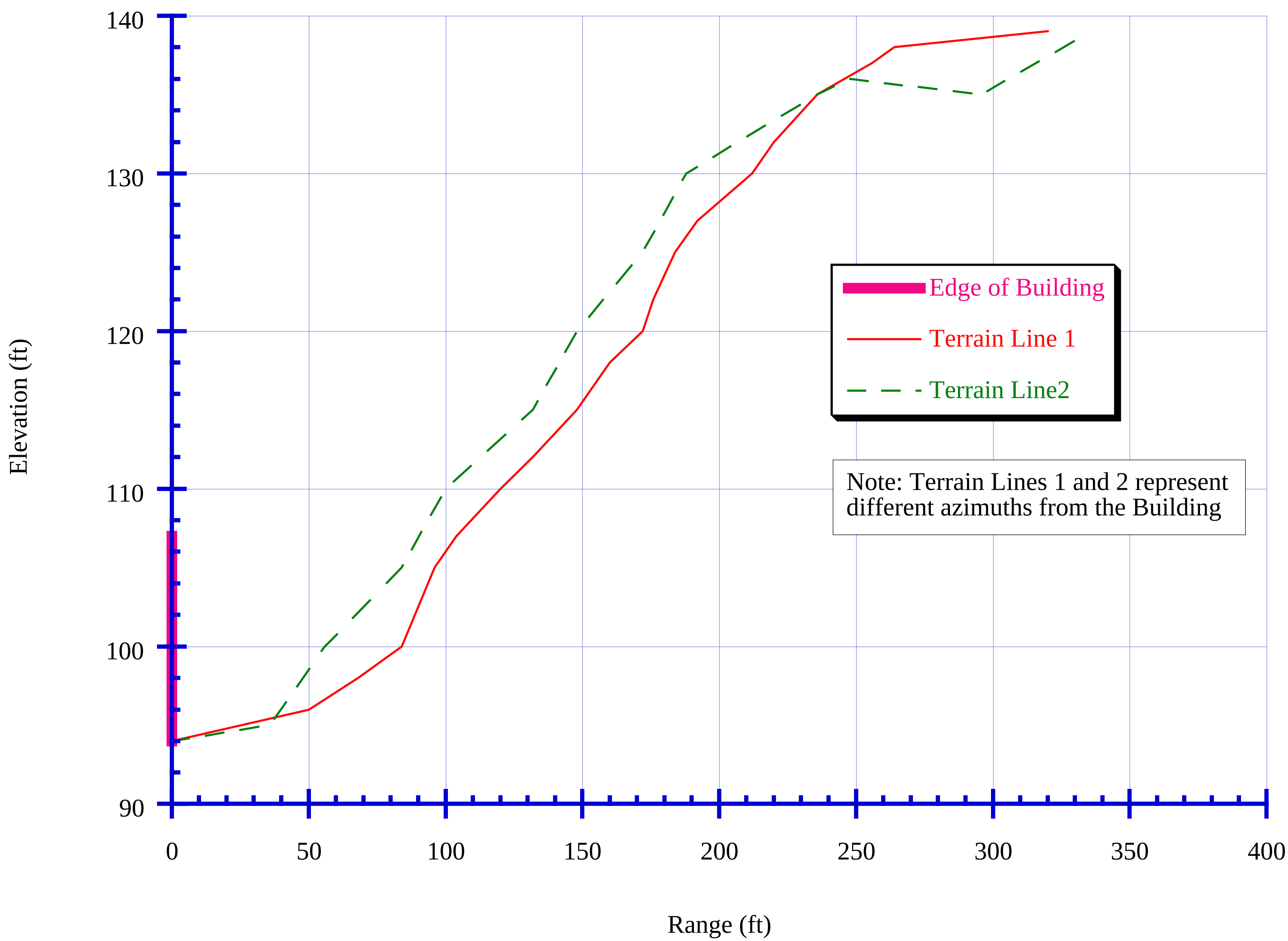

FIGURE 3: Explosive Processing Building (Top View)